ON SOME INSECT GALLS ON *TECTONA GRANDIS* LINN. FROM INDIA[1]

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(With seven text-figures)

Anatomical investigations are made on three foliar galls and one shoot-axis gall on *Tectona grandis* Linn. caused by different gall-midges. Two of the foliar galls are reported for the first time. The stem gall is a lateral outgrowth of rinden-gall type. Several larval cavities occur in the vicinity of the cambial zone and cause distortion of that part of the cambium nearest the larvae. The gall grows due to proliferation of the cortical tissues. The foliar galls are circular, discoid and lenticular with a central short stalk. Anatomically these three foliar galls exhibit subtle differences, while the trichomes occurring on the gall surface differ quite considerably. The same tissues of the host plant respond differently to the different species of the gall-midges indicating that the host tissues have different latent morphogenetic potentials and the cecidozoa are specific to invoke the expression of a particular potential.

This paper deals with four insect galls on *Tectona grandis* Linn. collected by Prof. M. S. Mani and the author near Trivandrum during May, 1980. Three of these galls arise on leaf and one on the branch axis; two of the leaf galls are new. The galls appear about the same time and are nearly all equally abundant. Brief descriptions, with notes on the anatomical characters and mode of development of these galls are given below. The galls are identified by characteristic numbers, which are continuation of the system given by Mani in his PLANT GALLS OF INDIA (1973).

A. SHOOT AXIS GALL

Gall No. 280 by *Asphondylia tectonae* Mani (Mani 1948, 1959, 1973)

This gall was listed as early as 1899 by Stebbing, erroneously as a 'Cynipid' gall and the error was continued by Sundar Raman in 1924. It was first correctly recognized as a midge-gall by Mani in 1948 (op. cit.), who later described the midge reared from the gall in Top Slip (Anamalai Hills) by Dr Sen-Sharma. The gall seems to be widely distributed along the Western Ghats and parts of the Vindhya-Satpura, where teak forests occur. The following anatomical notes form a supplement to the general description of the gall by Mani (op. cit.).

The normal young stem of *Tectona grandis* is typically four-angled and has a narrow periderm, followed by indistinct cortex. The vascular cylinder approximates to the general quadrate outline of the stem section (Fig. 1). The secondary wood is diffuseporous with narrow rays. Two or three concentric narrow bands of libriform fibres occur in the region of secondary phloem. The secondary xylem is composed of vessels with simple perforations and pitted lateral walls (Fig. 2-A) and short, wide-lumened fibres (Fig. 2-B). The parenchyma cells containing crystals also occur in the secondary xylem.

The gall arises as a lateral outgrowth of cortex. The larva seems at first to penetrate in between the secondary xylem and the cam-

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bium. The part of the cambial zone nearest the larva grows out into several distorted strands that later come to be embedded in the gall tissues (Fig. 1). The remote side of the stem develops practically normally.

In a transverse section of the gall the outermost region consists of periderm, which is slightly thicker than in the normal stem. Beneath this lies a broad zone of parenchyma, mixed with an abundance of brachy-sclereids (Fig. 2-C). Inside of this peripheral zone there are several larval cavities scattered at different levels radially about the cortex of the axis. Each larval cavity is elliptical (Fig. 1), surrounded by broad zones of concentric parenchyma cells (Fig. 2-D). The innermost layer of cells lining the cavity are collapsed. The vascular strands in the parenchyma zone consist of tracheary elements with reticulate lateral wall thickenings (Fig. 2-E) and all converge toward the larval cavities (Fig. 1).

B. FOLIAR GALLS

The normal leaf consists of an even layer of thickly cuticularised, rectangular adaxial epidermal cells (Fig. 3-A). The abaxial epidermis is rugose and consists of small cubical cells with the stomata on the ridges. Uni- or multicellular, uniseriate, unbranched, acute hairs and stalked glandular trichomes with multicellular spherical head are copious on the lower surface (Fig. 3-B). The short thick unicellular acute hairs, with heavily cuticularised walls account for the general roughness of the upperside of the blade. The mesophyll consists of two layers of elongate narrow palisade cells. The cells of the first row are longer than those of the second row. The spongy parenchyma has two or three layers of irregular cells. The vascular bundles occur in the spongy mesophyll and the major veins have parenchymatous bundle sheath with adaxial and abaxial extensions.

Gall No. 414 by Gall-midge (Mani 1953, 1959, 1967, 1973).

Hypophyllous or epiphyllous, circular, discoid lenticular gall, about 3 mm in diameter and 1 mm in thickness, inserted on the blade by a narrow, short, central stalk. The first visible indication of the development of gall is a cushion of hairs, which grow denser and turn thickly villous on the mature gall. Transection of the early gall is flat and lenticular, with a small adaxial conical projection and a wide abaxial covering-growth over a shallow larval chamber (Fig. 4-A). The larval cavity opens to the outside by a large ostiole through a narrow passage, lined by straight, short, thick-walled hairs directed outward to the ostiole. The abaxial surface of the gall is clothed with soft, multicellular, dichotomously branched hairs, while the adaxial surface remains almost glabrous. In the transverse section of a young gall three tissue zones are recognised : (1) the adaxial epidermis and its periclinal derivatives alligned in vertical files; (2) a bowl-shaped meristematic zone, around the larval cavity, consisting of small cells with dense cytoplasm and prominent giant nuclei; and (3) an intermediate zone between these two, with the cells vertically elongated and vacuolated. A narrow two-celled layer, at the junction of the vacuolated and meristematic zones below the larval chamber, soon differentiates into sclereids (Fig. 4 A-C). At a later stage, arises lignification of the cells bordering the ostiole and the larval chamber, and vacuolation of the cells around the ostiole, thus delimiting the meristematic zone in the form of hollow circular disc around the larval chamber (Fig. 4-A). The cells of the meristematic zone divide in the anticlinal plane and the derivatives expand radially so that the gall becomes disc-shaped.

On maturation of the gall the meristematic zone turns into a dark tissue, around the small larval cavity and extends down below as a

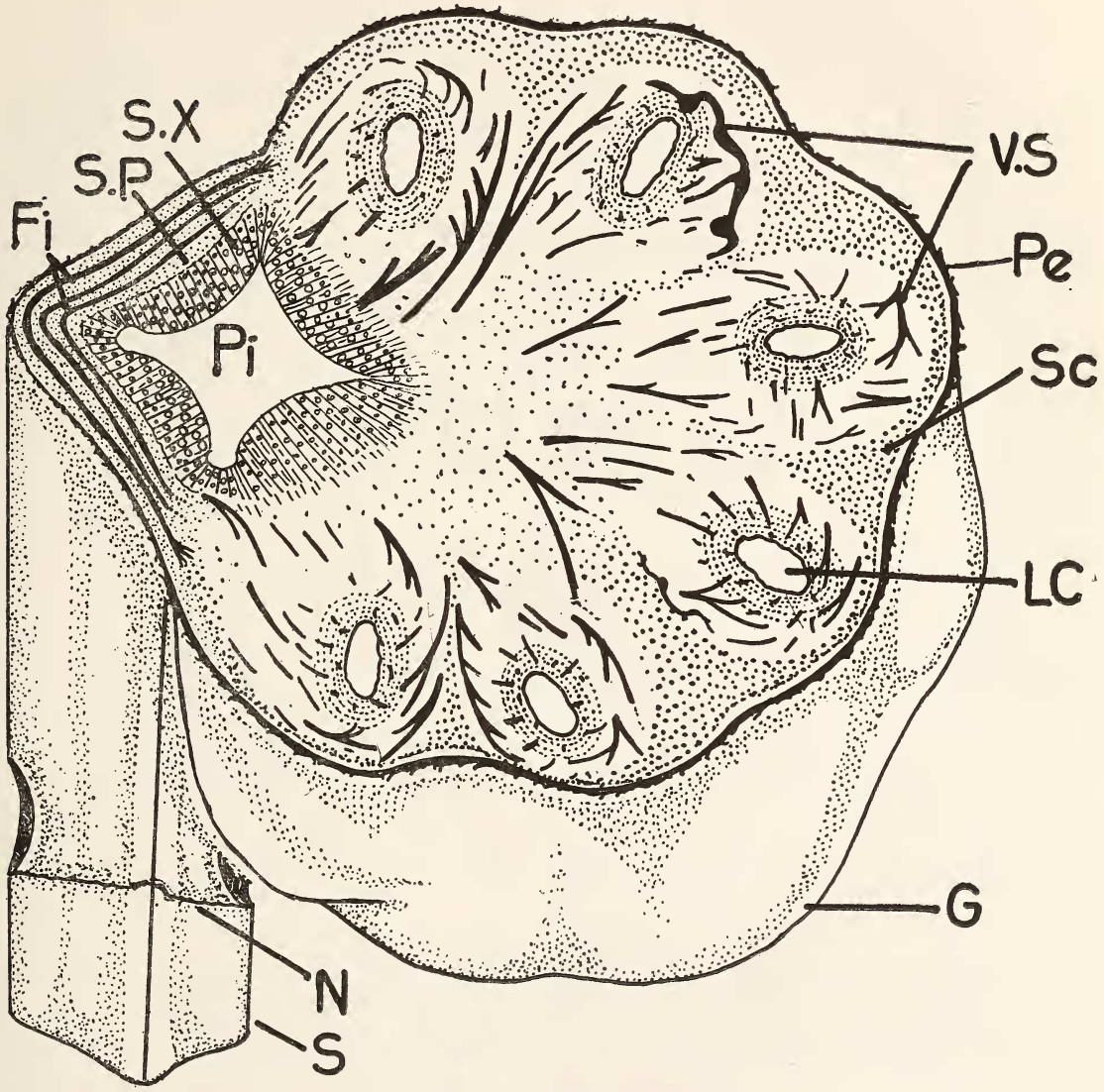

Fig. 1. *Tectona grandis* Linn. Gall No. 280
Stereoscopic diagram of the shoot axis gall caused by *Asphondylia tectonae* Mani. (Fi—Fibres; G—Gall; LC—Larval Cavity; N—Node; Pe—Periderm; Pi—Pith; S—Stem; Sc—Sclereids; S. P—Secondary Phloem; S. X—Secondary Xylem; V. S—Vascular Strands.)

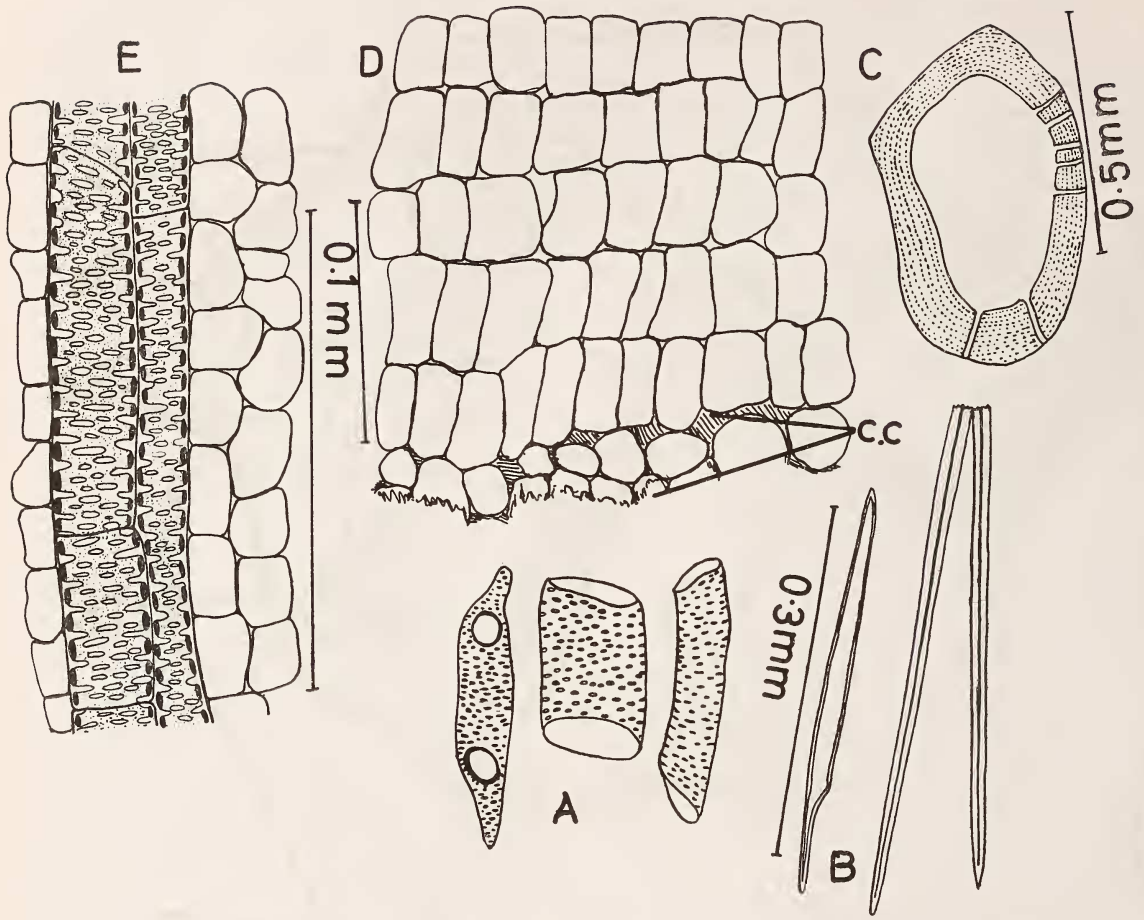

Fig. 2. *Tectona grandis* Linn. Shoot-axis Gall.
A. Vessel elements of normal stem; B. Xylem and cortical fibres of the normal stem; C. Brachysclereid of the gall; D. Storied arrangement of the cells around the larval cavity; E. Lateral wall thickenings of the tracheary elements of the vascular strands in the gall. (C.C—Collapsed cells around the larval cavity.)

thick pillar axially in the middle of the stalk of the gall (Figs. 5-A, B). Two or three layers of cells on the boundary of the dark zone differentiate into sclerotic zone. Clusters of prismatic crystals occur in the cells of the dark zone and in the lumen of the sclereids. Outer to the sclerotic zone is the compact, thin-walled, parenchyma zone, the cells of which are elongated parallel to the surface. The vascular strands of the leaf extend into the gall through the stalk radiating around the gall cavity. The surface layer of the gall gives rise to a characteristic densely matted long-branched trichomes. The base of each trichome arises from a pyramid of compact cells (Fig. 5-C). The hair cells are elongate, uniseriate and cylindrical with granular contents. Apart from this type of trichomes, a second type, which

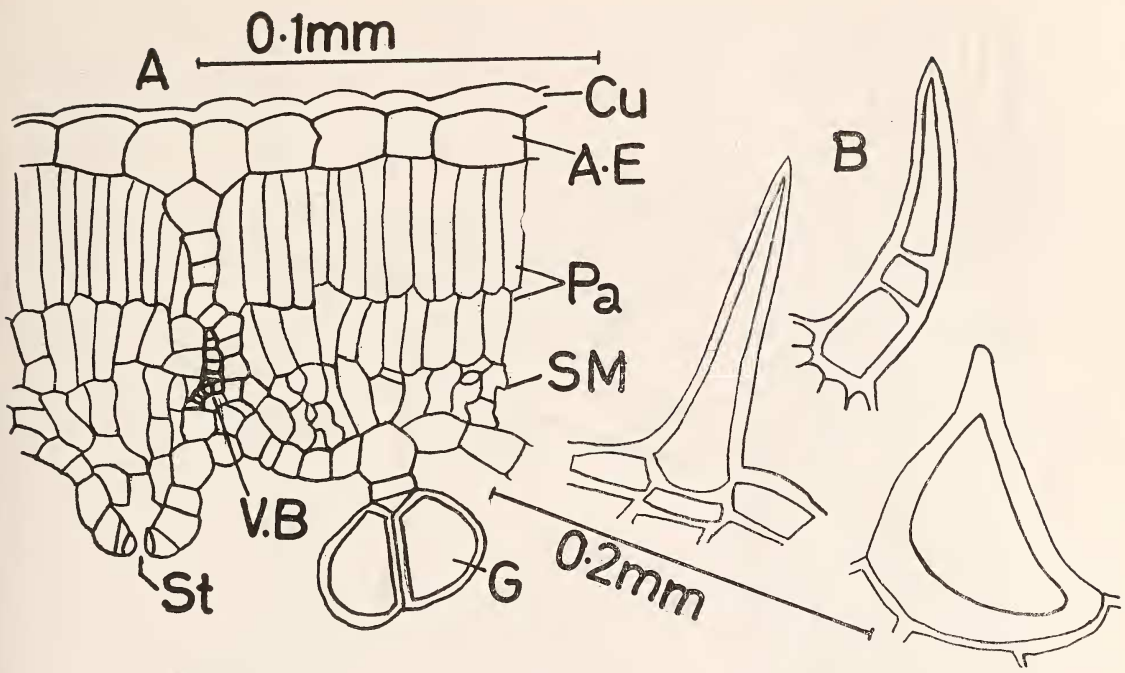

Fig. 3. *Tectona grandis* Linn.
Structural of the normal leaf and epidermal hairs.
A. T.S. of normal leaf; B. Three types of epidermal hairs on the leaf.
(A.E—Adaxial epidermis; Cu—Cuticle; G—Gland; Pa—Palisade tissue; SM—Spongy Mesophyll; St—Stoma; V.B—Vascular bundle.)

is shorter, thicker and thick-walled, also occurs mixed with the first type (Fig. 5-D).

Gall No. 899 by Gall-midge

This gall is wholly hypophyllous, but with a conspicuous epiphyllous chlorotic depression. The gall is 3 mm in diameter and 1 mm thick; pale yellow, subsessile and cup-shaped with the ostiole at the centre of depression (Fig. 6-C). The surface lacks the long brownish hairs, but is clothed with short thick-walled acute trichomes.

The course of development of this gall is more or less similar to that of gall No. 414. The gall arises as a hemispherical covering-growth with median larval cavity (Fig. 6-A). A cup-shaped meristematic zone develops around the larval cavity, which foreshadows the shape of the mature gall. The meristematic cells divide in vertical plane and grow radially, resulting in the formation of a discoid growth with a central ostiole (Fig. 6-B). Soon, the cells abutting the meristematic zone differentiate into a thin layer of sclerotic cells. The sclerotic zone extends down as a central pillar-like axis inside the stalk. The essential difference between gall Nos. 414 and 899 is in the trichomes. In the gall No. 899, the surface is densely clothed with short, stumpy, unicellular and multicellular branched hairs with extremely thick lignified walls with canal-like pits (Fig. 6-D). As these trichomes are short and dense, the surface of the gall appears smooth to the unaided eye.

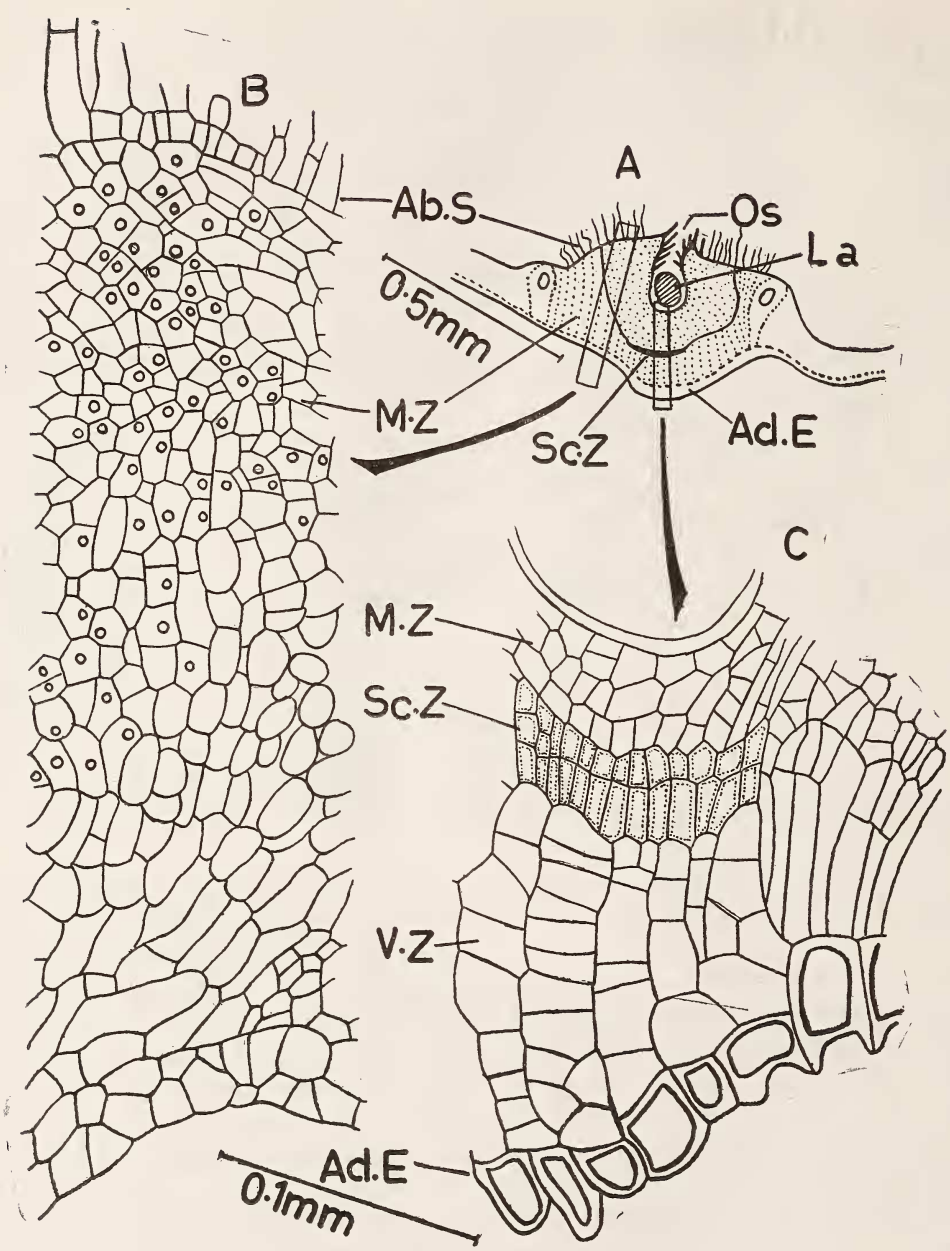

Fig. 4. *Tectona grandis* Linn. Foliar gall No. 414
A. An early stage of the gall; B, C. Two sectors of the Fig. A shown as insets. (Ab. S— Abaxial surface with epidermal trichomes; Ad. E—Adaxial Epidermis; La—Larva; M. Z—Meristematic Zone; Os—Ostiole; Sc. Z—Sclerotic zone just differentiating; V. Z—Vertically elongated cell zone.)

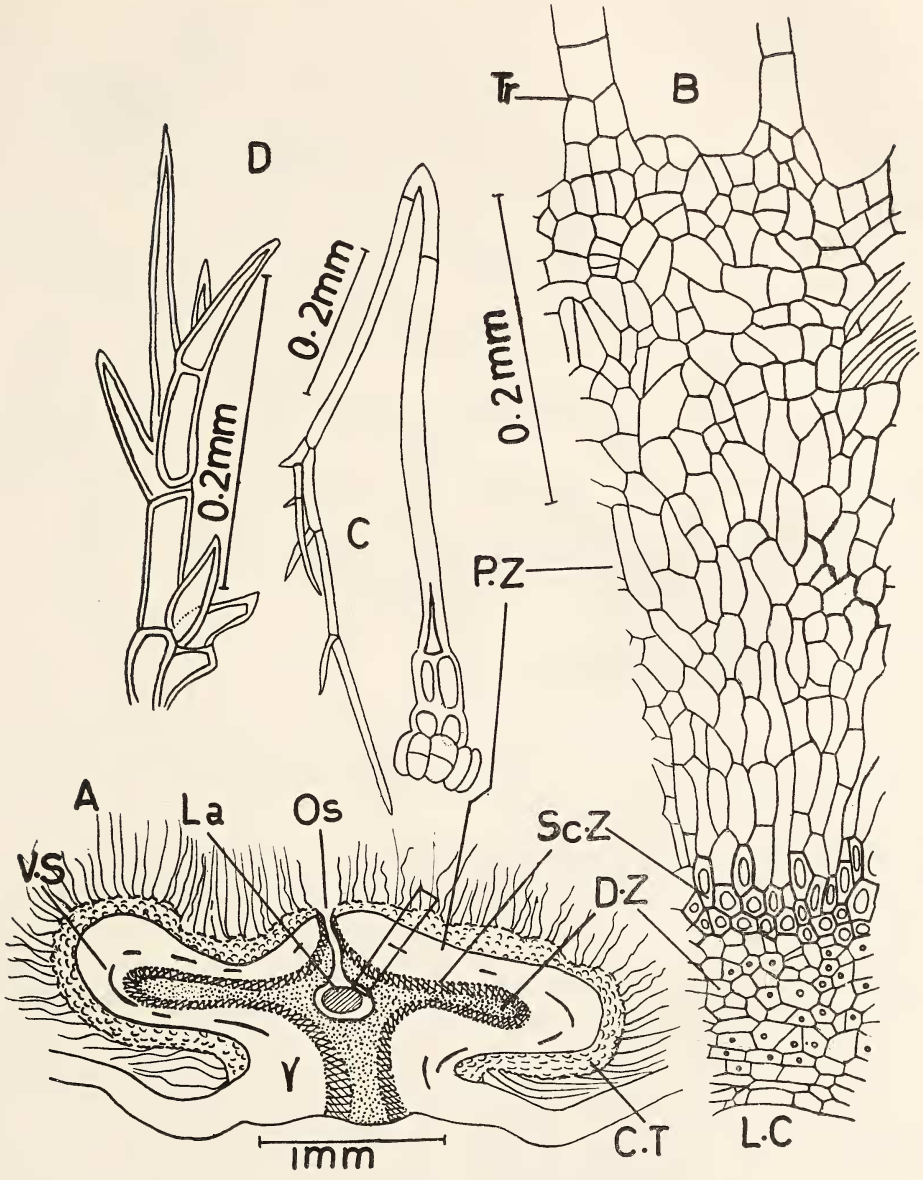

Fig. 5. *Tectona grandis* Linn. Gall No. 414

A. Vertical section of a mature gall; B. A sector of the Fig. A shown as inset; C, D. Two types of trichomes occurring on the gall surface.

(C.T—Cushion of cells from which the trichomes arise; D.Z—Dark cell zone; La—Larva; L.C—Larval chamber; Os—Ostiole; P.Z—Parenchyma zone; V.S—Vascular Strand; Tr—Trichomes.)

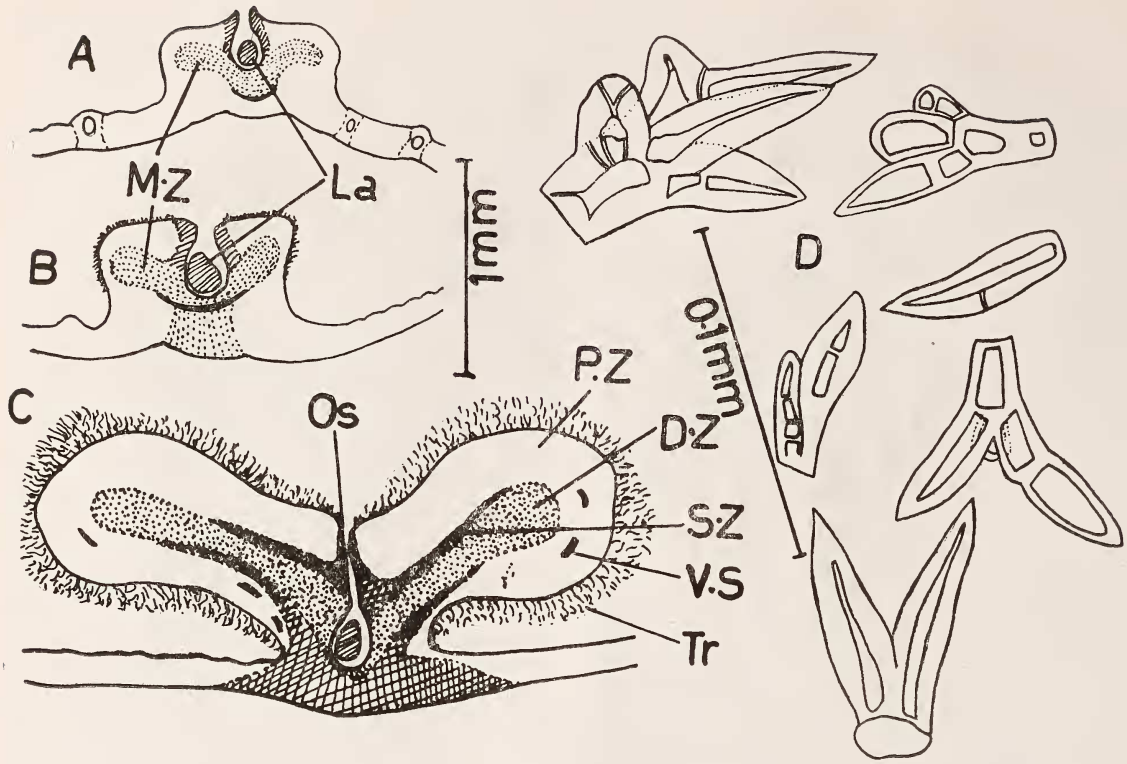

Fig. 6. *Tectona grandis* Linn. Gall No. 899
A, B. Two developmental stages of the gall; C. Vertical section of a mature gall; D. A few representative types of trichome of the gall.
(D.Z—Dark cell zone; La—Larva; M.Z—Meristematic zone; Os—Ostiole; P.Z—Parenchyma zone; S.Z—Sclerenchyma zone; Tr—Trichomes; V.S—Vascular Strand.)

Gall No. 900

Though this gall shares certain features with other two, there are basic differences. This is a lenticular gall, mostly hypophyllous, only sometimes epiphyllous, white or pale yellow, discoid and subsessile covering growth, with a short, stumpy subconical projection in the middle of the disc, where opens the ostiole (Fig. 7-A). On the lower surface of the gall, around the stalk, occur long, branched, filamentous hairs similar to those of the gall No. 414. The upper surface bears two different types of trichomes — glandular trichomes with large spherical unicellular knob and multicellular uniseriate stalk and short multicellular branched hair clusters (Fig. 7-B, C). This trichome differs from those of the gall No. 899 in the thin cell walls and larger size of cells. The larval cavity is a large circular strongly depressed, biconvex space, occupying almost to the middle of the disc (Fig. 7-A). The larval cavity is surrounded by a zone of deeply staining cells, which in turn is ensheathed by the sclerotic zone which extends below as a broad column axially into the stalk, where the sclereids are vertically elongated. The outermost zone of the gall consists of parenchyma cells arranged in layers parallel to the gall surface. This zone is vascularised as in other galls.

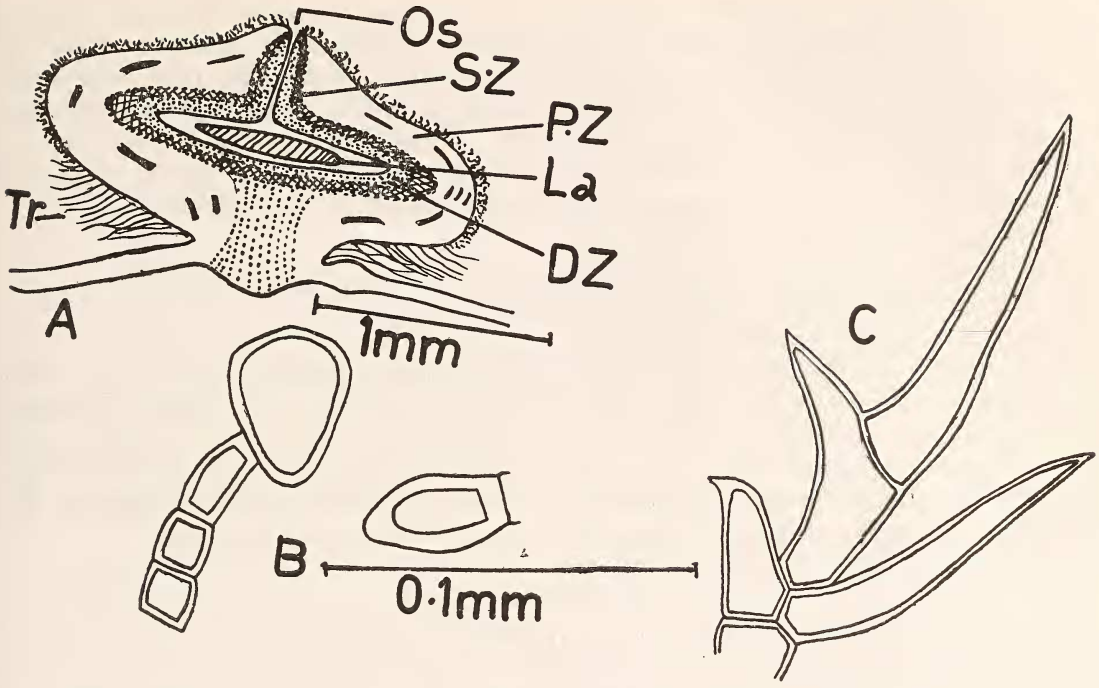

Fig. 7. *Tectona grandis* Linn. Gall No. 900
A. Vertical section of a mature gall; B, C. Trichome types of the gall.
(DZ—Dark cell zone; La— Larva; Os—Ostiole; P.Z—Parenchyma zone; S.Z—Sclerenchyma zone; Tr—Trichomes.)

Discussion

The three types of foliar galls on *Tectona grandis* display similar basic organisation inspite of certain definite structural differences. In the gall Nos. 414 and 900, there is a small central conical projection bearing the ostiole at its summit (Figs. 5-A; 7-A). In the gall No. 899, a shallow circular umbilicus-like pit is seen with the ostiole at the centre (Fig. 6-A). All the three gall types have darkly staining, small celled nutritive zone around the larval cavity followed by the sclerotic and parenchyma zones. The gall surface develops specific type of trichomes in each case, all of which differ from the trichomes of the normal leaf. The ground tissues on which these three different types of gall are built up are the same. However, they respond differently to the three different species of gall-midges, indicating that the same tissues react in different morphogenetic ways and the stimulatory agents of the cecidozoa are specific to invoke the expression of a particular potential.

It is generally believed that the epidermal tissue is relatively passive with regard to its meristematic potential (Linsbauer 1930). It is interesting to observe that in the foliar galls of *Tectona grandis,* the epidermis and its appendages are equally sensitive and reactive to the insect stimuli.

The stem gall on *Tectona grandis* induced by *Asphondylia tectonae* Mani is remarkable in its anatomical aspects. Several radially dis-

posed larval chambers occur at different levels of the gall. The cecidogenetic stimulus greatly influences the vascular cambium as a result of which the meristem is torn into several strands which ultimately differentiate into long reticulately pitted elements (Fig. 2-E). These vascular strands surround the larval chambers and serve as *'fascieux de irrigation'* reported in several galls (Mani 1964). The cortical parenchyma is greatly proliferated and some of them differentiate into brachysclereids; but they do not form definite sclerotic zone. The parenchyma cells around the larval chamber are alligned in regular concentric whorls consequent to repeated anticlinal divisions. In this respect, this tissue differs from the wound callus formed in the lepidopterous galls in which the cells are arranged in radial files due to repeated periclinal divisions. The elements of the gall tissues differ fundamentally from those of the normal stem. The stem tissues are influenced both quantitatively and qualitatively by the cecidogenetic factors and deviate from their normal course of morphogenesis.

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